The Space Network Alternative

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The Space Network Alternative

Mission Services Program Office

The MSPO is responsible for Program Planning, Direction and Operation of NASAs Space flight Tracking and Data Network (STDN)

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Background

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White Sands Complex

- TWO FUNCTIONALLY IDENTICAL, GEOGRAPHICALLY SEPARATED GROUND TERMINALS AT THE WHITE SANDS TEST FACILITY
- THE WSC HAS FIVE SPACE TO GROUND LINK TERMINALS (SGLTs)
  - A SIXTH SGLT HAS BEEN INSTALLED AT THE REMOTE GROUND TERMINAL ON GUAM AS AN EXTENDED WSC SGLT
- THE WSC ALTERNATIVE RESOURCE TERMINAL (WART) FUNCTION IS USED TO COMMAND AND CONTROL TDRS-1 AND PROVIDES S-BAND (SSAF/SSAR) AND K-BAND (KSAR) SERVICES TO NSF ONLY
    - SERVICES UNABLE TO SUPPORT ON-ORBIT USERS

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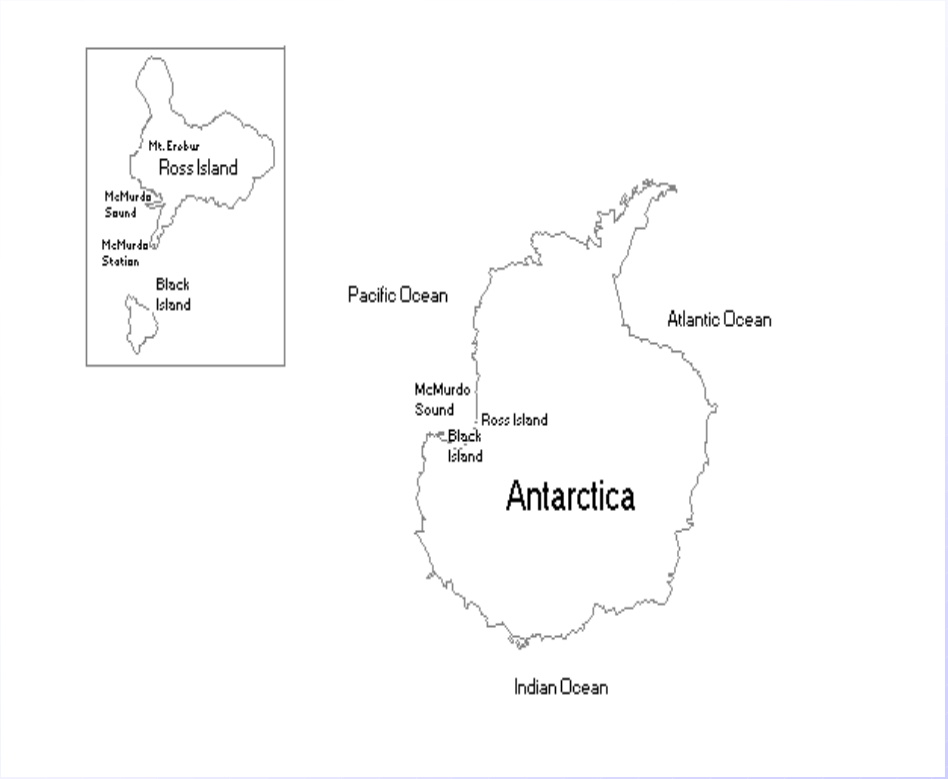
McMurdo/TDRSS Relay System (Demonstration)

- McMurdo/TDRSS Relay System
  - Two K-band relay sites will be accessible to the GN McMurdo Ground Station in Antarctica
  - Capable of Near Real-Time telemetry throughput from MGS to WSC via TDRS 171W/174W
  - Data Rates up to 150 MBPS can be supported
  - WSC has data interface into EDOS/EBNET for data transfer to GSFC for EOS MOCs



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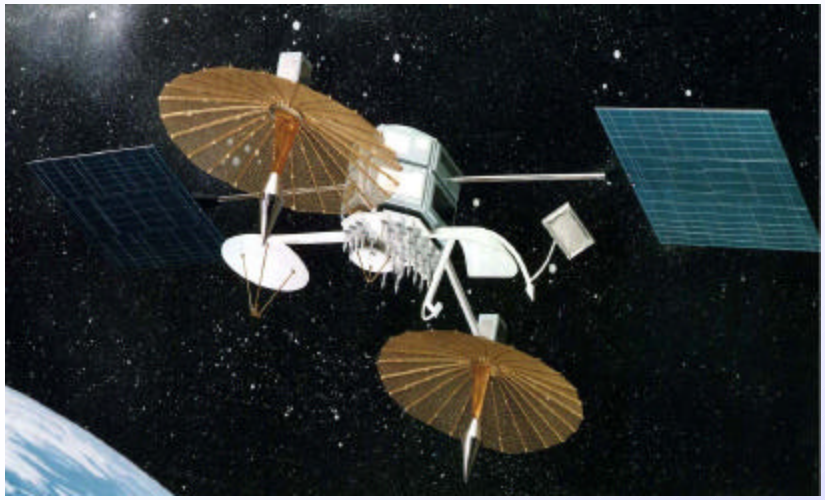
Tracking and Data Relay Satellites

First Generation TDRS
F-1 through F-7



Second Generation TDRS
F-8 through F-10

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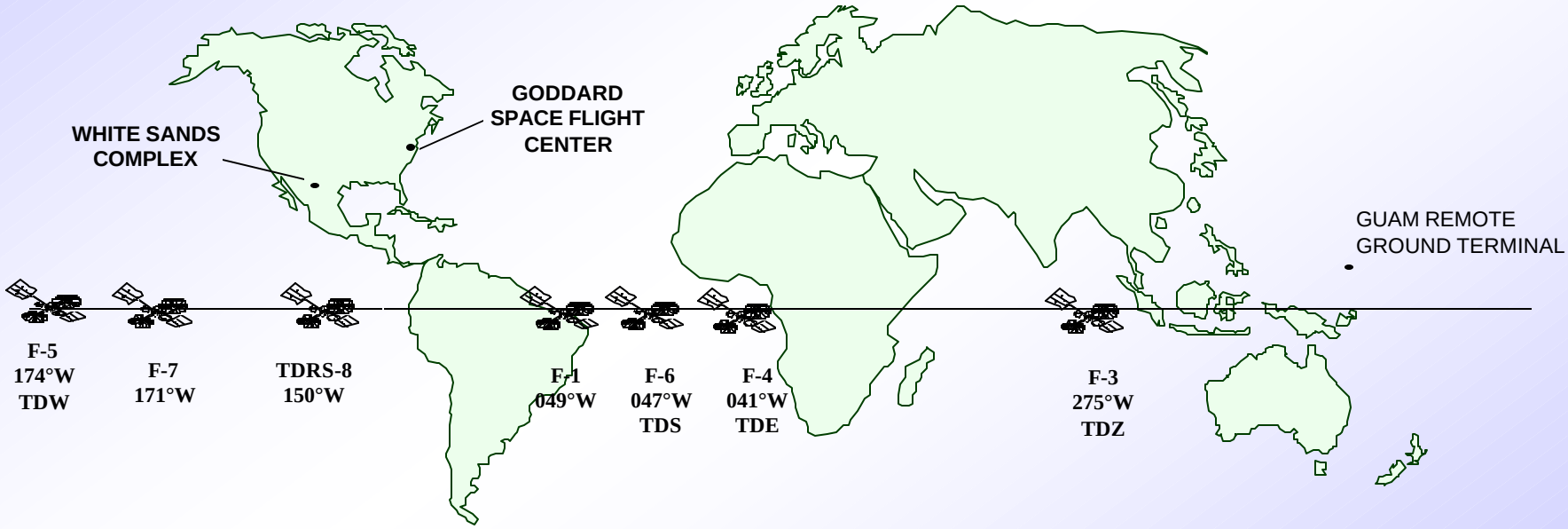
Present TDRSS Constellation



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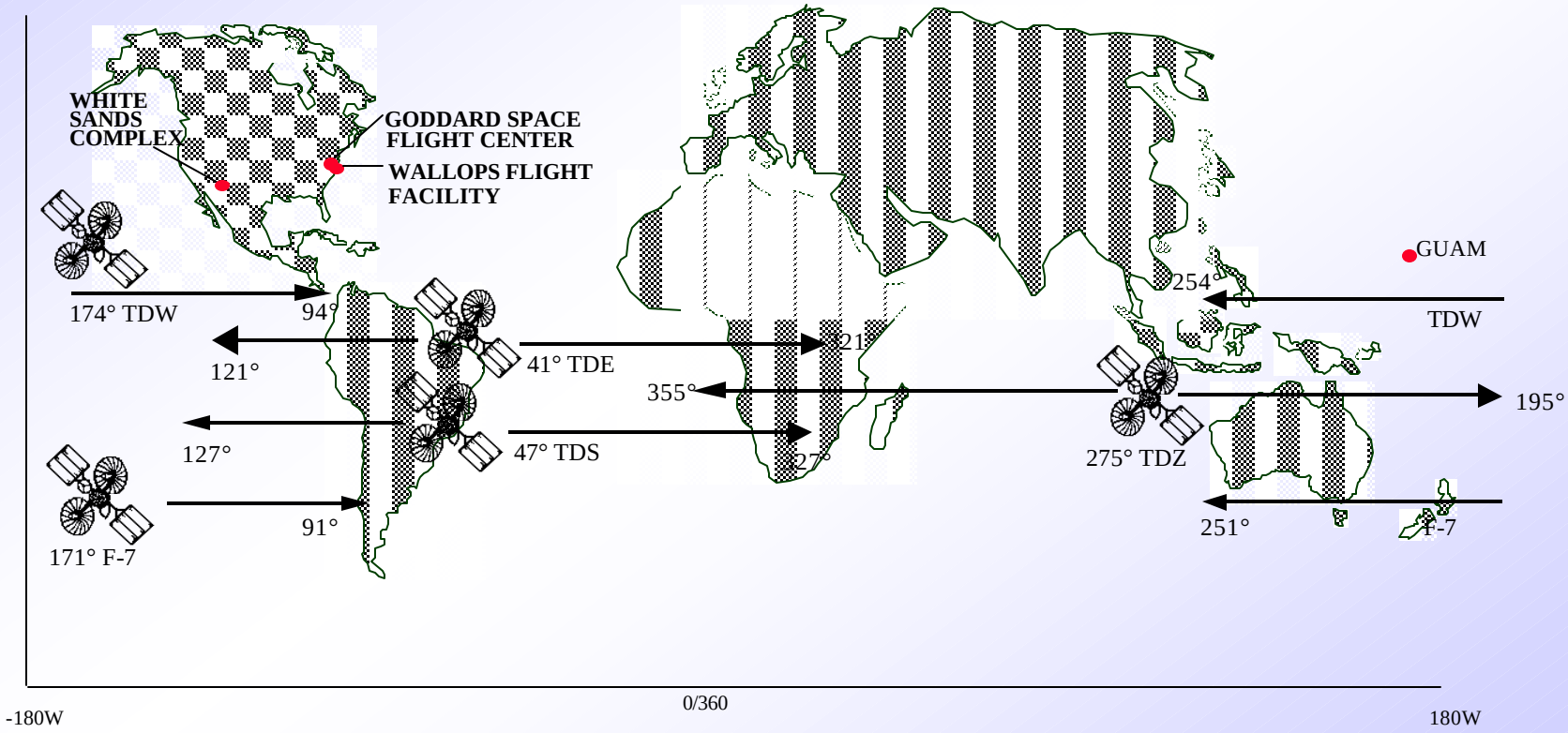
TDRSS Fields of View



TDRS VIEWS BASED ON 600KM USER ALTITUDE AT THE EQUATOR

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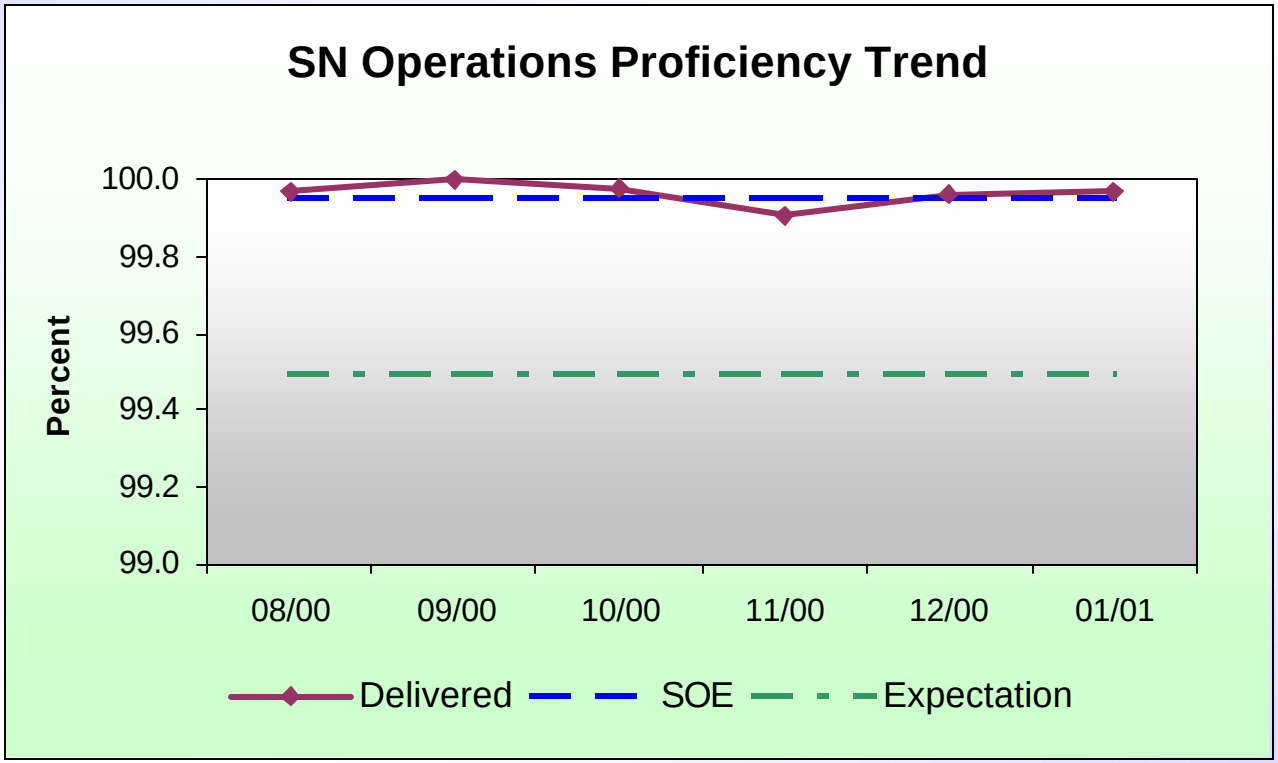
SN Proficiency



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Pre-Mission Services

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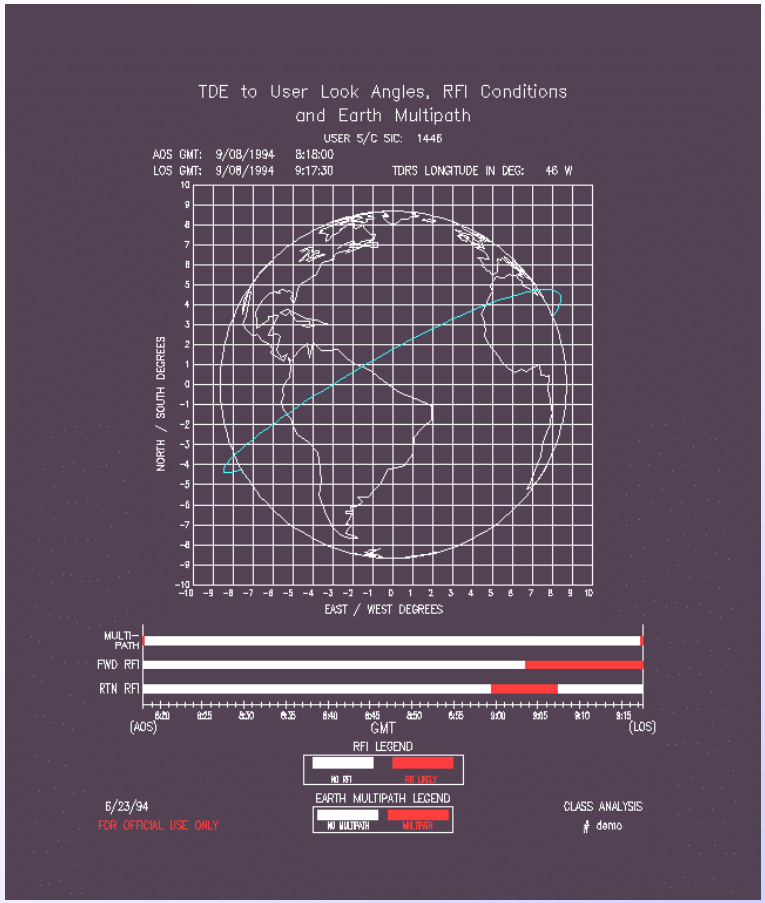
TDRSS Services

- Mission Planning
  - Computer Link Analysis System (CLASS)
    - Static Link Margin Analysis
    - Dynamic Link Analysis of Actual trajectory/orbit to determine TDRS coverage periods (Value-added powered flight, orbit insertion)



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TDRSS Services (cont'd)

- Operations Planning
  - Implementation of network enhancements to support evolving generic and unique customer requirements
- Testing
  - Provide characterization, IV&V and compatibility testing for mission readiness
  - Proficiency and abort simulations
  - Testing Resources
    - Compatibility Test Van
    - Direct Support via Pad or rooftop antenna
    - RF SOC

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TDRSS Services (cont'd)

- Pre Launch Support
  - Payload and Launch Vehicle RF checkout
  - Vector Verification testing
- Launch Support
  - Provide acquisition data to WSC for launch support
  - Real time tracking and data acquisition of launch vehicle and payload for separation and orbital insertion
  - Near real time data for Polar Orbiters utilizing MGS and MTRS

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Direct Mission Support

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SN Support of GN Mode Operations

- SN can provide Command/Telemetry and Tracking support for GN mode S-Band Communications
  - Typically 1 to 2 kbps Command
  - 8 to 16 kbps telemetry (using omni antenna on spacecraft)

- Advantages
  - Provides support for on-orbit S/C emergencies
    - Single TDRSS view up to 50 minutes using WSC and GUAM
  - Lower transponder costs
  - Occasional support can be handled via manual scheduling (verbal/email) precluding additional costs to the MOC for hardware and interfaces (Presumes support parameters are already in the NCCDS)

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Expendable Launch Vehicle Support

- Proven Track Record for ELV support (see backup material for current and future ELV customers)
- Provides advantages for receiving telemetry data as well as advantages to Project Control Centers
  - Expanded geometric coverage for critical events for flexible mission profiles
  - Eliminates costly methods of receiving telemetry
  - Almost no data latency
  - Variety of data rates, frequencies and modulation types can be supported

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Spacecraft Launch and Early Orbit

- SN support typically includes:
  - Launch Vehicle and Payload command and telemetry from pad testing through early orbit
  - Launch Vehicle and Payload acquisition data for launch and early orbit
  - Proficiency and abort simulations
- SN provides telemetry and command support
  - SN mode of operations
  - GN mode of operations
- SN provides tracking data to FDF for downrange tracking and initial orbit determination
  - FDF processes and evaluates inertial guidance system (IGS) and LTAS data received at FDF. Compares real-time data to current data being used by SN
  - FDF processes LV telemetry to obtain initial orbit determination
  - Provides real-time acquisition updates to SN as required

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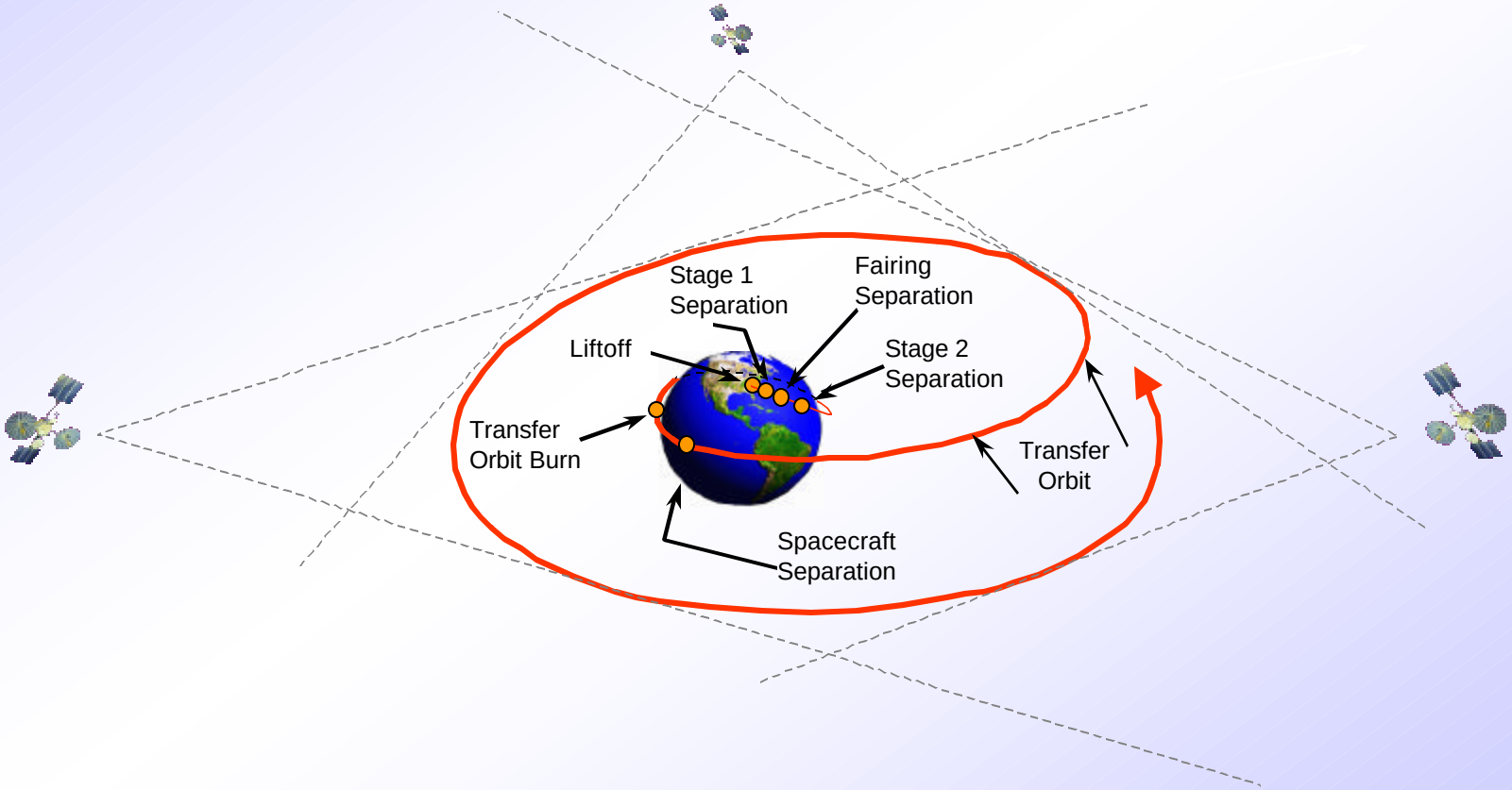
Global Coverage for Mark Events



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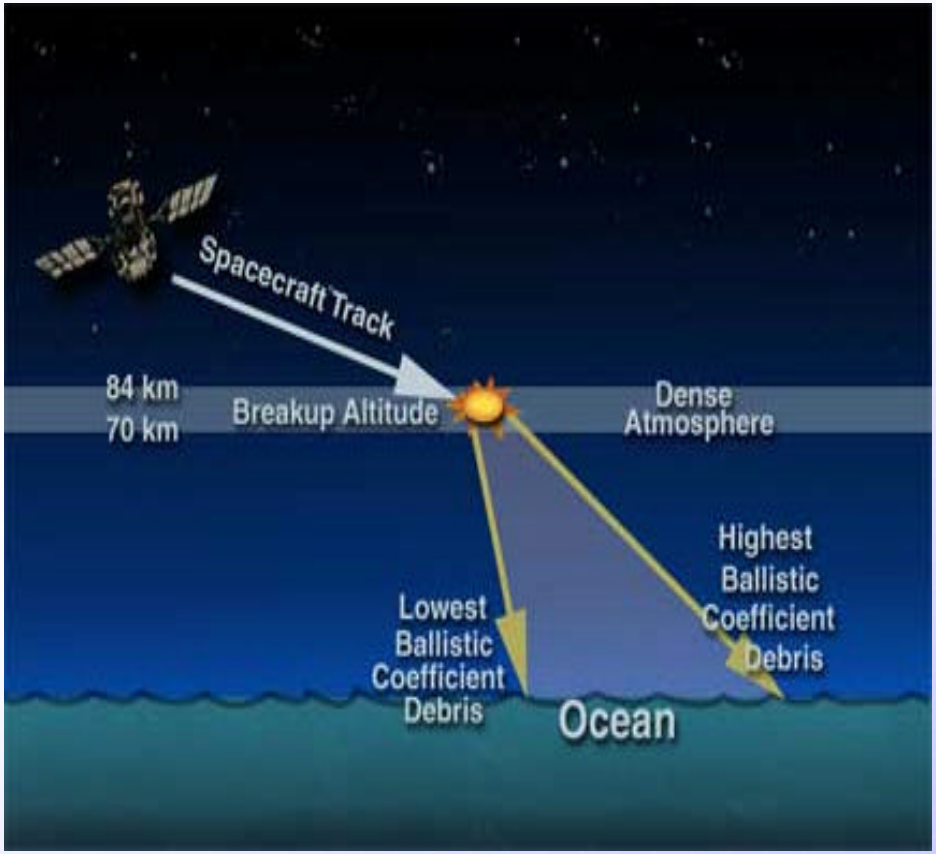
Spacecraft Reentry Support

- TDRSS was used as prime support for CGRO Reentry at mission termination. TDRSS held link until just prior to breakup. TDRS LOS at 90 km
- Dynamic analysis of communication coverage provided by CLASS for MOC planning of reentry activities
- FDF analysis of de-boost trajectories to develop de-boost acquisition data plan
- SN can provide coordination with other space tracking networks or agencies.
- Missions currently planning reentry
  - EUVE early 2002
  - TRMM late 2002



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TDRSS Services (cont'd)

- Line Outage Recording
  - Data recorded at WSC in the event of NISN circuit failures
  - Near real-time delivery of recorded data

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Space Network Success Stories

- EO-1
  - GN tracking data unusable by FDF
  - NORAD C-band radars tracked the wrong object
  - TDRSS was the only system to correctly acquire and provide valid 1 and 2 way tracking data to FDF and MOC
  - Ongoing CMD/TLM with GN transponder

- NOAA-L
  - Planned ARIA Relay support for Launch and Early Orbit
    - ARIA on-board emergency cancelled first launch attempt
    - ARIA mechanical difficulty resulted in a no-show for the next launch attempt
  - TDRSS was planned for tracking data but was not intended to provide telemetry support due to calculated negative link margins
    - Decision was made to attempt telemetry acquisition
    - TDRSS successfully closed link and for the first time provided real-time telemetry for NOAA spacecraft separation and deployment
    - TDRSS is now being baselined for NOAA M, N and N' missions

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Space Network Success Stories (cont'd)

- FUSE
  - SN supported L&EO telemetry and best effort Command (WSC Crash Cart)
  - SN provided critical support when Puerto Rico Ground station was damaged due to adverse weather
  - FUSE carried out a complete flight software reload via TDRSS. Extended TDRSS view significantly decreased the time necessary to perform the reload

- CGRO
  - Loss of recorders drastically reduced science data collection to in-view real-time downlink
  - SN implemented GRTS effectively closing the ZOE thereby providing near 100% real-time coverage
  - Implementation of GRTS enabled the CGRO mission to meet its science objectives

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FDF Successes With the SN Customer Community

- Titan B-32 Mission (April 30, 1999)
  - Non-nominal burn during launch,
    - FDF responded by using its unique software capabilities to update the TDRS pointing data to ensure spacecraft acquisition during this critical mission phase.
- TDRS-H Early Orbit Operations
  - FDF assumed primary orbit determination responsibilities after unforeseen processing problems prevented Hughes from performing this task
- ETS-7 Docking Anomaly
  - Planned SN and ETS support only after NASDA Relay satellite failure
  - FDF provided critical OD data during docking anomaly
  - SN and FDF support resulted in meeting nearly 100% of the science objectives

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The Future

- MAP
  - Critical Burns to L-1 (Command, telemetry and tracking)
- TIMED
  - Launch and Early Orbit (Command, telemetry and tracking)
- GALEX
  - Launch and Early Orbit (Command, telemetry and tracking)
- VCL
  - Launch,Early Orbit (Command, telemetry and tracking)

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Technology

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Demand Access

- Demand Access Service (DAS)
  - Available March 2002
  - Dedicated 24 X 7 MAR service for customer support via TDRS 1-7 (MAF is not included in DAS)
  - Initially 8 new receivers at WSC followed by implementation of 8 additional receivers at Guam
  - Unlimited expansion of DAS services is possible
  - Scheduled and Controlled via SWSI interface
  - TCP/IP telemetry data connectivity via NISN open or closed IONET circuits

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Web Based SN Services

- SN Web Services Interface (SWSI)
  - Available in March 2002
  - Provides SN service scheduling and real-time control of TDRSS services
  - NISN interfaces available for open and closed IONET
- WSC TCP/IP Data Interface Service Capability (WDISC)
  - Provides TCP/IP connectivity for TDRSS Command and Telemetry services
  - Data interface available to both open and closed IONET NISN circuits
  - WDISC schedules are currently submitted verbally or by Briefing Message to NCC. Minimum turnaround of 20 minutes to obtain services when requested verbally
- FDF Product Server
  - Provides general and mission specific products in support of flight project missions (LOF, TDRS IIRVs, OE)

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Fourth Generation Transponder

- TDRSS/GN Compatible
- Low Power Consumption
  - 6 Watts for Receiver
  - 34 Watts for Rx/Tx (w/5 Watt transmitter output)
- Lightweight – 8 lbs.
- Small Profile 8”L X 6.3”W X 5.2” H
- Ku-Band Transmitter Exciter Option
  - Adds 1lb and 5 Watts power consumption
  - Motorola has 14 units on order
  - Gravity Probe (2), X-38 (2), National Scientific Balloon Facility (4), EOS-PM (2), EOS Chem (2), SWIFT (2)
  - Cost ≈ 1.1 Mil

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Low Power Transceiver

- TDRSS/GN Compatible
  - Integrated 12 channel receiver for SN/GN/GPS
  - Tx power options from 1 Watt to 25 Watts
- Low power consumption
  - 8 Watts for Receiver
  - 11 Watts with 1 Watt HPA
- Lightweight – 6.7 lbs.
- Low Profile – 4.68” X 5.33” X 4.25”
- Being considered for ELV/EELV Range Safety application and On-Orbit Spacecraft
- Will fly aboard STS-107 (4/2002) as a Hitchhiker experiment for Proof-of-Concept and qualification
- Cost ≈ 300K – 400K

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Multimode S-Band NASA/GN Transceiver

- TDRSS/GN Compatible
- Low Power Consumption
  - 6 Watts for Receiver
  - Transmitter options under development
- Being considered for On-Orbit and Slow moving ground based applications
- Motorola has 18 MMTs on order
  - X-37 (8)
  - National Scientific Balloon Facility (9)
  - C/NOFS (1) COMM/NAV Outage Forecasting System (AFRL)
  - Cost ≈ 300 K – 400 K

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Resources

- TDRSS Online Information Center
  - A comprehensive online resource with current and detailed information on all aspects of TDRSS and the Space Network
  - This presentation can be found contained in this website
  - http://nmsp.gsfc.nasa.gov/tdrss/
- Document and Data Control System Online Library
  - A website that provides easy access to MSPO technical documentation
  - http://csoc-ddcs.csoconline.com/library/
- David Zillig for information regarding the Fourth Generation Transponder, LPT and MMT
  - David.J.Zillig.1@gsfc.nasa.gov
- Demand Access Website
  - http://stelwscpo.gsfc.nasa.gov/Das/
- FDF Product Server
  - http://mmfd.gsfc.nasa.gov/FDD_products.html

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Don’t leave earth without it

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Backup

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ELV Support

Current ELV Customers

- TITAN/CENTAUR (MAY 94)
  - 128 KB
- ATLAS/CENTAUR (JAN 96)
  - 512 KB
- SEALAUNCH (MARCH 99)
  - 512 KB
- ATLAS III (MAY 00)
  - 256 KB/200 KB (I/Q)
- NAVY P3 RELAY
- TITAN –16 KB
- DELTA II (2^{ND} STAGE) – 17 KB
- DELTA II (3^{RD} STAGE) – 9.6 KB
- PEGASUS – 116KB
- IUS – 64 KB

Future ELV Customers

- DELTA IV (EELV)
  - 192 KB
- ARIANE V (ATV MISSION FOR ESA)
  - 250 KB
- H-IIA (NASDA)
  - 131 KB
- KISTLER AEROSPACE (REUSABLE)
  - 100 KB
- ATLAS V (EELV)
  - UNKNOWN (ANTICIPATED SAME AS ATLAS III)

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The Flight Dynamics Facility

- Provides
  - Orbit Determination
  - Trajectory Analysis - for support optimization
  - Acquisition Data
  - Tracking Data Evaluation
- For
  - STS -- including contingency and yaw steering support
  - ELV -- including yaw steering and variable azimuth support
  - ISS and Orbiting Spacecraft -- Including orbit determination using one-way Doppler
  - De-orbiting spacecraft -- e.g., CGRO, TRMM
  - Non-space vehicles -- e.g., Aircraft, ships, balloons, quasars
  - International Customers -- e.g., Ariane, ETS-VI/VII
- Via
  - Unique Interfaces
  - Network Interfaces
  - The Internet -- FDF Products Server
- Using
  - Automated systems
  - COTS products and new technologies integrated with mission proven legacy systems
- As needed
  - Assists other SN elements in problem resolution
  - Provides analysis for future missions

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Service Summary/System Capacity

	FREQUENCY	SERVICE	MAX. DATA RATE	SERVICES PER TDRS [1]	WSC [4] CAPABILITY	GUAM CAPABILITY
SINGLE ACCESS S BAND	2020.4 MHz - 2123.3 MHz	FORWARD	300 kbps	2	10	2
	2200 MHz - 2300 MHz	RETURN	6 Mbps	2	10	2
Ku BAND	13.747 GHz - 13.802 GHz	FORWARD	25 Mbps	2	10 [2]	2
	14.887 GHz - 15.119 GHz	RETURN	300 Mbps	2	10 [2]	2
Ka BAND	22.55 GHz 23.55 GHz	FORWARD	25 Mbps	2	6 [2]	0
	25.25 GHz 27.50 GHz	RETURN	300 Mbps 800 Mbps	2 1	6 [2] 0 [3]	0
MULTIPLE ACCESS S-BAND (1-7)	2103.1 MHz - 2109.7 MHz	FORWARD	10 kbps	1	4	1
	2284.5 MHz - 2290.5 MHz	RETURN	150 kbps	5	20	2
SMA (H,I,J)	2284.5 MHz – 2290.5 MHz	RETURN	6 Mbps	6	18	0

Notes:

1. Fully operational S/C
2. Ku and Ka FWD/RTN Service is Shared on the TDRS/WSC SGL. Simultaneous Ku and Ka Service Is Not Possible
3. Ka-Band (H,I,J) 800 Mbps is not supported on the Ground (WSC)
4. 4 SGLTS at WSC are capable of supporting the H,I,J S/C. WSC Ka-Band and SMA capability reflect the 6/18 respectively because there are only 3 H,I,J S/C

2 way ranging and 1 and 2 way Doppler tracking available

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TDRS/TDRS H, I, J Service Comparison

SERVICE			TDRSS	TDRS - H,I,J	NOTES
SINGLE ACCESS	S-BAND	FWD	300 kbps	300 kbps	NO CHANGE
		RTN	6 Mbps	6 Mbps	
	Ku-BAND	FWD	25 Mbps	25 Mbps	
		RTN	300 Mbps	300 Mbps	
	Ka-BAND	FWD	N/A	25 Mbps	23/25-27 GHz frequency band
		RTN	N/A	800 Mbps	
	NUMBER OF LINKS PER SPACECRAFT		2 SSA 2 KuSA	2 SSA 2 KuSA 2 KaSA	FOR TDRS H,I,J SIMULTANEOUS OPERATION OF S & Ku AND S & Ka SERVICES A SINGLE SA ANTENNA ARE REQUIRED
MULTIPLE ACCESS	NUMBER OF LINKS PER S/C	FWD	1 @ 10 kbps	1 @ 10 kbps (8 dB over TDRSS)	ANTICIPATED SSA USERS LESS THAN 3 Mbps OFFLAOADED TO TDRS H,I,J MA
		RTN	5 @ 150 kbps LIMITED BY GROUND EQ. ONLY	6 @ 3 Mbps (ONBOARD BEAMFORMING)	
CUSTOMER TRACKING			150 meters 3 sigma	150 meters 3 sigma	NO CHANGE